CHANGING DIATOMS OF DEVILS LAKE

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During the summer of 1915 I spent some time at the Biological Station of the University of North Dakota at Devils Lake, investigating the diatoms of the lake. Before this considerable diatom material had been sent to me by Dr. R. T. YOUNG of the University, who is conducting the biological survey of the lake.

The immediate practical object in the survey is to determine the organisms in the lake in relation to the fish that might be able to subsist upon them, and diatoms being the most abundant of microscopic plants, deserve special attention in this connection. At present the stickleback, *Eucalia inconstans*, is the only species of fish in the lake, notwithstanding the fact that food is abundant. This species, however, is common.

The lake is passing through a rapid transition. It was formerly a fresh-water lake fed by streams, and at that time it contained large numbers of fish, but the lake is rapidly becoming lower. From 1883 to 1912 it fell 14 ft., a fall of about half a foot a year. It has now no apparent inlet or outlet, and the water is becoming salt. The salinity, however, is quite different from that of sea water. It differs somewhat in different parts of the lake and at different seasons of the year, but the following analyses made by Dr. F. H. HEATH of the University of North Dakota in the summers of 1914, 1915, and 1916 will give a general idea of the condition of the water. No complete analysis was made in 1915, but the total amount of solids in that year was greater than in 1914 or 1916, due to the lower level of the water.

	1914	1915	1916
Carbonate (CO_3)	254	213	.....
Bicarbonate (HCO_3)	447	639	.....
Silica (SiO_2) variable	370	.....	242 and 69
Sulphate (SO_4)	6231	.....	6706
Fe_2O_3 and Al_2O_3	.....	.....	121
Calcium (Ca) variable	.....	.....	86.5
Magnesium (Mg)	598	.....	579
Chlorine (Cl)	1106	.....	1284
Total solids	11,980	14,477	13,020

These analyses show about 1 per cent of solids in the lake, or about one-third of the amount in ocean water. This comparatively rapid increase in salinity has produced a corresponding change in the diatoms of the lake, as well as in all the other organisms that it contains. We have no knowledge of what diatoms were in the lake when the water was fresh, but we can safely assume that they were all of species commonly found in fresh water elsewhere, perhaps the same as in Court Lake, a fresh-water lake which was formerly a part of Devils Lake.

In my work I identified 56 species of diatoms in the lake. Of these, 25, as reported elsewhere, are genuine fresh-water species; 20 are species that are found in either fresh or brackish water; 3 are in brackish water only; 2 are reported as being found in fresh, brackish, or salt water; 2 in brackish or salt water; and 4 as marine only. It is possible that when the water in the lake was fresh 50 of these species, that is, all but the 4 marine ones and the 2 that are brackish or marine, were living in it; however, this is not likely. It is probable that there was then a much larger proportion of fresh-water species, as there usually is in fresh water, and fewer of those of varied habitat. As the water became more saline, however, diatoms adapted to either fresh or brackish water gained a foothold, then those adapted to either brackish or salt water, and finally the 4 marine species. One of these marine species, *Chaetoceros elmorei* Boyer, classed as marine because the genus is a marine one, was identified by C. S. BOYER as a new species. It is not likely, however, that it originated in this lake, and it is probably to be found elsewhere.

The importation of marine species so far inland is easily accounted for. It would be perfectly possible for them to be carried in the air, but adhering to migratory birds is a much more probable explanation.

The 25 species of fresh-water diatoms present the greatest anomaly. There is nothing in their appearance to indicate that they have been in any way modified by their changed environment.

There are several smaller lakes in the vicinity of Devils Lake which were formerly part of the main lake, but have been separated from it by the lowering of the water. The analysis of the water

made in 1916 by HEATH shows the total solids in the main lake to be 13,020, or about 1.3 per cent; in Minnewaukon Bay above the grade, 0.4464 per cent; Court Lake, 0.12 per cent; and Lake I, 0.1328 per cent. The water in all of these lakes shows the same large amount of magnesium sulphate.

These conditions of salinity are correlated with interesting differences in the diatoms. The portion of Minnewaukon Bay from which the sample was taken was formerly part of the main lake and its water had about the same degree of salinity. But within the past year a highway grade has been made, cutting it off, and it is now connected with the main lake only by a culvert. Through this culvert the main lake receives about 2,000,000 gallons of water daily. This leaves the water in the bay practically fresh. In a collection made in this bay 14 species of diatoms were found, all but one of which are also found in the main lake. This one species, *Stephanodiscus niagrae*, is a fresh-water species. In this case a change in the condition of the water of from 1.3 per cent to 0.4464 per cent of solids has in one season made practically no change in the diatoms.

Lake I contains 0.1328 per cent of solids, or about one-third as much as Minnewaukon Bay. Instead of having been separated from the main lake only a few months, as in the case of Minnewaukon Bay, it has been separated for about 5 years. In this lake 24 species were found, 6 of which are not found in the main lake. These 6 are all fresh-water species.

Court Lake contains 0.12 per cent of solids, nearly the same as Lake I, but of the 22 species of diatoms found in it, 13 are not found in the main lake, and all of these 13 are fresh-water species; but Court Lake has been separated from the main lake for about 100 years. Since the main lake became salt, Court Lake has not been connected with it. These 13 species not found in the main lake, therefore, may have been originally in it and have died out on account of the saltness of the water; or they may have been introduced into Court Lake after the separation; or, what is more likely, some may have been in the original lake and others have been introduced later.

The fact that little change has been made in the diatoms by the change of water in the branch of Minnewaukon Bay would indi-

cate that diatoms are not very sensitive to such changes. Also, the fact that Lake I, which contains about the same amount of solids as Court Lake, but has recently been connected with the main lake, has a diatom flora much more like the main lake than like Court Lake, also indicates that diatoms are slow in responding to changes in environment.

No marine species were found in any of the outlying lakes, but as they are comparatively rare in the main lake, and the other lakes have been less carefully explored, this fact probably has no significance. More careful collecting may show them there also.

In a spring at Sully's Hill on the shore of the lake, but at an elevation of 50 ft. or more above it, 9 species were found, 3 of which were found in the lake and 6 not found in it. These probably have no relation to the diatoms of the lake, for there has never been any connection between the water of the two places, and these diatoms are all of species found commonly in fresh water everywhere.

In ditches along railroads and in pools 26 species were found, 17 of which were found in the main lake and 9 of which were not. The composition of the water in these places varies greatly. After rains, when they are filled, the water is practically fresh, but as it evaporates it becomes considerably concentrated. This, together with the fact that this land was once covered by the lake, explains the presence of the forms commonly found in brackish water. Some of these facts are summarized in following table I.

TABLE I

Place	Species in main lake	Not in main lake	Percentage of solids	Time separated from main lake	Habitat as reported elsewhere					
					Fresh	Marine	Fresh and brackish	Brackish	Marine or brackish	Fresh, brackish, or marine
Main Lake.....	56	0	1.3	.....	25	4	20	3	2	2
Minnewaukon Bay.....	13	1	0.4464	6 months	6	1	6	0	0	1
Court Lake.....	9	13	0.12	100 years	16	0	4	1	1	0
Lake I.....	18	6	0.1328	5 years	12	0	10	1	1	0
Pools and ditches	17	9	.....	.....	14	0	1	3	1	2

The diatoms of this region illustrate what has commonly been observed elsewhere, that many of them adapt themselves readily

to changes in environment. Here there are marine and fresh-water species living together under semimarine conditions, and in Minnewaukon Bay, where the water changed from saline to fresh, the diatoms that had been living in the saline water seemed to have been in no way affected in one season by the change. In Court Lake, the water of which has never been salt, there is one species whose habitat is reported as "marine or brackish." Its presence here may be explained by the nearness of Court Lake to salt water, making it easy for it to be introduced; and its continuing to live there may be explained by its adaptability to various environment.

Should the lake continue to diminish in size, its salinity will probably increase; and at the same time other bays will be cut off and become separate lakes. These changes will furnish interesting material for study, not only of the diatoms, but of all other organisms inhabiting the lake.

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